LASER OPTICS

LASER is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation

Laser – the device, is a highly coherent, monochromatic, intense and directional source of light or optical radiation. The basic principle involved in the lasing action is the phenomenon of **stimulated emission.** This phenomenon was predicted by Einstein in 1917.

ATOMIC OR ELECTRONIC TRANSITIONS:

Atomic or Electronic transition means the movement of atoms and electrons from lower energy level to higher energy level or vice versa. Accordingly there are two types of transitions.

a. Transition from lower energy state to higher energy state (Absorption):

Absorption of radiation is the process by which electrons in the ground state absorb energy from the incident photons and jump to the higher energy level. Absorption occurs only if the energy of incident photon is equal to the energy difference of two energy levels between which the transition occurs.

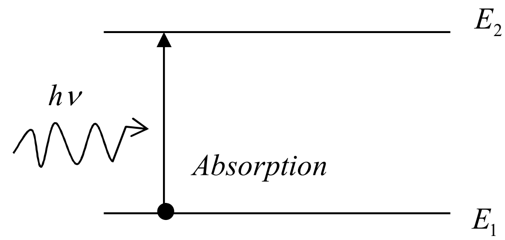
If, E_1 = The energy of lower level.

E_2 = The energy of higher level.

Then, $\left(E_2 - E_1\right) = h\nu$, Energy of Photon

Where, ν = Frequency of radiation.

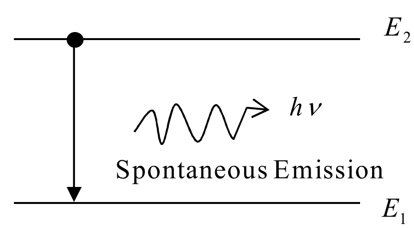
h = 6.626 X 10^{-34}J-S



b. Transition from higher energy state to lower energy state (Emission):

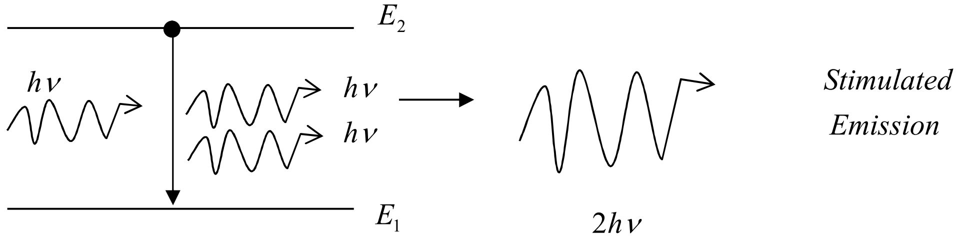
The emission process can be done in two ways.

i. **Spontaneous emission:** It is the process by which electrons from the excited state returns to the ground state by emitting photons. The time for which an electron remains in an excited state is of the order of 10^{-10}sec. After that it comes back to its ground state by emitting a photon.



(b)

ii. **Stimulated emission:** An atom in an excited level can also make a downward transition in the presence of an external radiation of frequency (E_2-E_1)/h. The most important aspect of thie type of transition is that the emitted radiation is coherent with the stimulating radiation. Thus stimulated emission leads to a coherent amplification of the incident stimulating radiation and is the process responsible for amplification of optical radiation in a laser



(c)

EINSTEIN'S COEFFICIENTS:

Let us consider an assembly of atoms in thermal equilibrium at temperature (T) with the radiation of frequency ν and energy density $\rho(\nu)$. Under this condition all three transitions that is, stimulated absorption, spontaneous emission and stimulated emission occur simultaneously.

Let N_1 –No. of atoms per unit volume in the lower energy state E_1

N_2- No of atoms per unit volume in the upper energy state E_2.

Now, the rate of stimulated absorption $\propto N_1$

and $\propto \rho(\nu)$.

$\Rightarrow$ Rate of stimulated absorption = $B_{12}N_1\rho(\nu)$.

where, B_{12} is called as **Einstein's Coefficient of absorption**

Once the atoms are excited by stimulated absorption, they return to the normal state spontaneously (on their own) after their life time expires. As a result spontaneous emissions of photons take place.

Now, Rate of spontaneous emission $\propto N_2$

$\Rightarrow$ Rate of spontaneous emission = $A_{21}N_2$

where A_{21} is the **Einstein's coefficient of spontaneous emission.**

Some of the atoms in the excited state may interact with photons resulting in stimulated transition to the lower energy state. So stimulated emission occurs.

Now,Rate of stimulated emission $\propto N_2$

and,$\propto \rho(\nu)$.

$\Rightarrow$ Rate of stimulated emission = $B_{21}N_2\rho(\nu)$

where, B_{21} is the **Einstein's coefficient of stimulated emission.**

Under thermal equilibrium, the absorption and emission rates are equal.

So, $$B_{12} N_1 \rho(\nu) = B_{21} N_2 \rho(\nu) + A_{21} N_2$$

$$\Rightarrow \rho(\nu) = \frac{(A_{21}N_2)}{[(B_{12}N_1 - B_{21}N_2)]} \qquad (1)$$

According to Boltzmann's distribution law,

$$N_i = g_i N_0 e^{-E_i}/KT$$

Where N_i –population density in the energy level E_i

N_0 is the population density at temperature T (Kelvin)

g is the degeneracy of the I[th] level

K is the Boltzmann constant

So, $N_1 = g_1 N_0 e^{-E_1/KT}$ *and* $N_2 = g_2 N_0 e^{-E_2/KT}$

Therefore, $$\frac{N_1}{N_2} = \frac{g_1 N_0 e^{-E_1/KT}}{g_2 N_0 e^{-E_2/KT}}$$

$$\Rightarrow \frac{N_1}{N_2} = \frac{g_1}{g_2} e^{(E_2-E_1)/KT}$$

$$\Rightarrow \frac{N_1}{N_2} = \frac{g_1}{g_2} e^{h\nu/KT} \qquad (2)$$

Using equation (2) in equation (1), we can write,

$$\rho(\mathrm{v}) = \frac{(\mathrm{A}_{21}/\mathrm{B}_{21})}{\left[\left\{(\mathrm{B}_{12}/\mathrm{B}_{21})(\mathrm{g}_1/\mathrm{g}_2)\ \mathrm{e}^{\mathrm{h}\nu/\mathrm{kT}}\right\}-1\right]} \qquad (3)$$

From Planck's black body radiation, we know,

$$\rho(\mathrm{v}) = \frac{8\pi h\nu^3}{c^3}\frac{1}{\mathrm{e}^{h\nu/KT}-1} \qquad (4)$$

Comparing equation(3) and (4), we can write,

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3} \quad \text{and} \quad g_1 B_{12} = g_2 B_{21}$$

The above two relations are called as **Einstein's relations**.

Under normal condition of thermal equilibrium, spontaneous emission is the dominating process.

<u>POPULATION INVERSION:</u>

For Lasing action to occur, the number of electrons or atoms per unit volume in the higher level must be more as compared to the lower level. The condition in which the higher level in an atomic system is more populated than a lower level is called as population inversion.

Mechanism of population inversion (Mathematical treatment):

From Maxwell-Boltzmann's distribution law (equation(2),

$$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT} \quad taking, g_1 = g_2$$

$$\Rightarrow \left(N_2 - N_1\right) = \Delta N = N_1 e^{-(E_2 - E_1)/KT}$$

As R.H.S. of above expression contains negative exponential term, so, ΔN is always negative

$\Rightarrow N_2 < N_1$

This indicates that, incident photons on the system have more probability to interact with atoms in the lower energy state than the atoms in the excited state, that means probability is more for stimulated absorption than for stimulated emission. So, to have more stimulated emission, population inversion (inverted population) must be achieved.

Population inversion is referred to as **negative temperature state** because from the above mathematical expression, ΔN is positive ($\Rightarrow N_2 > N_1$) only at absolute negative temperature But it is a mathematical concept not a reality.

By supplying required energy that means by giving external radiation of suitable frequency to an atomic system, population distribution changes and under certain conditions, population inversion can be achieved between two energy levels. This mechanism of achieving population inversion is called as pumping.

PUMPING:

Pumping is the technique to achieve population inversion. In a simple way it can be explained as a method to supply energy to an assembly of atoms so that more number of atoms will be excited to the higher levels and hence become more populated than the lower level. There are different types of pumping.

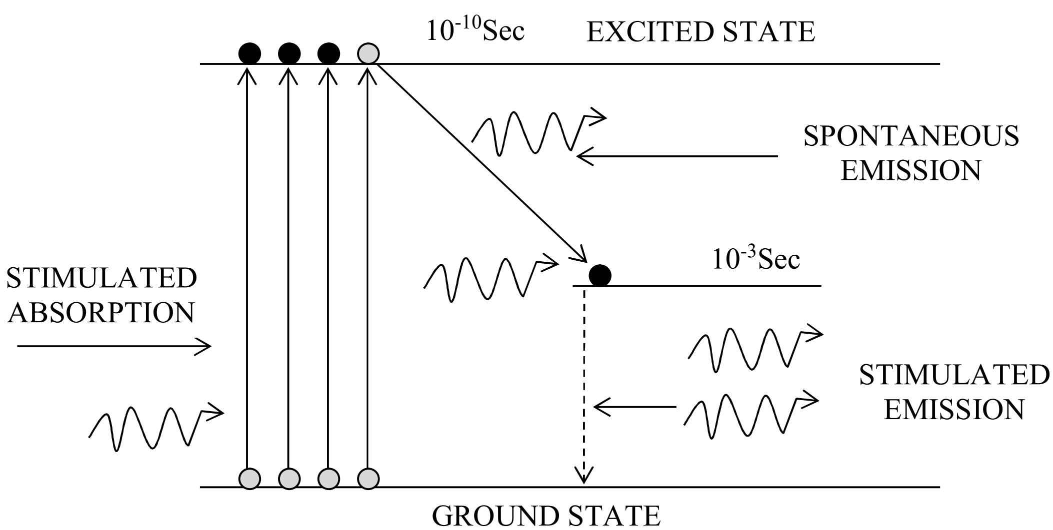
a. **Optical pumping**: Here an external light source is used where photons of suitable frequency allow ground state atoms to move to the excited states. Most conventional sources of this type of pumping are flash discharge tubes (Xenon flash lamp), LED & other laser sources. Optical pumping is used in ruby lasers.
b. **Solar pumping**: In this method sunlight is focused on a sapphire sphere (Al_2O_3) adjoined to one end of a Ruby rod by means of a parabolic mirror.
c. **Electrical pumping**: The light of an electrically exploding wire is utilized in exciting an active material in LASER. An exploding wire is a very powerful source of light. The wire is placed in one of the focus lines of an elliptical reflector made from stainless steel. The Ruby rod is disposed on the other focus lines of the reflector. The wire is exploded by high current pulses. This method is used to produce super powerful LASERS.
d. **Chemical Pumping:** Here certain chemical reactions result in excitation of atoms and population inversion is achieved.

e. Nuclear Pumping: By using nuclear power sources such as nuclear reactors, the population can also be achieved.

f. Cathodoluminescent Pumping: It is based on the principle of use of Cathode Ray Tubes. The cylindrical surface of this tube is coated with phosphorus. The Ruby rod is placed axially inside the cathode ray tube. The phosphorus is luminescent when it is bombarded by electrons. The radiant energy of such luminescence causes population inversion.

NEED FOR DIFFERENT LEVEL LASER SYSTEM:

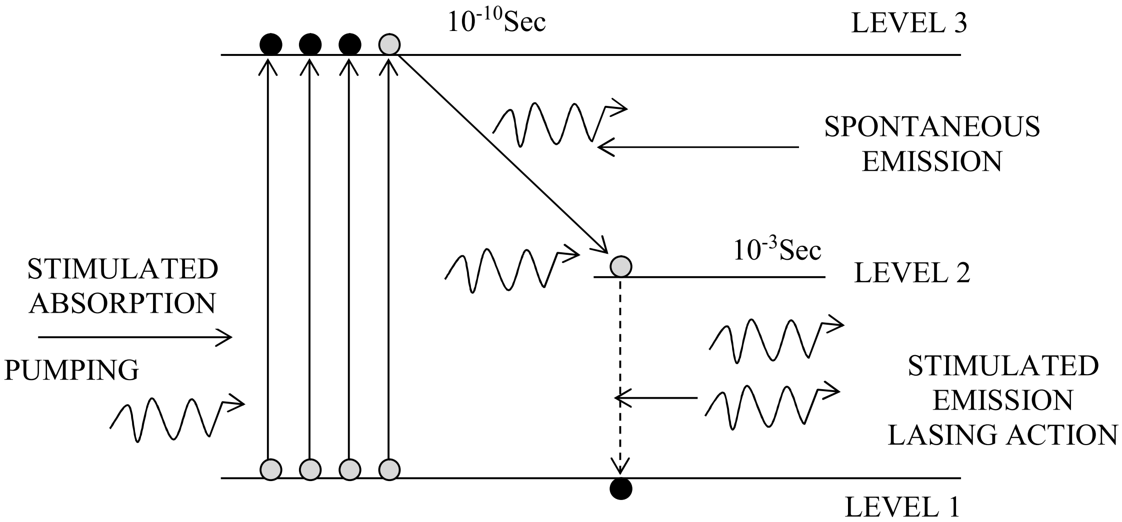
Though lasing action takes place between two energy levels, practically we need minimum three energy levels for useful operation of the laser. Because, if there are two levels one higher(meta stable) and other one (lower) ground level, by pumping action both absorption and stimulated emission occur simultaneously and hence population inversion cannot be obtained. Population inversion is possible when the stimulated absorptions occur to a higher energy level and stimulated emission takes place from a meta stable state which prevents pumping from depopulating the meta stable state.



a. Three level laser system

In a three level LASER system, there is a ground state and two excited states of an atomic system. When this atomic system is irradiated with a radiation of certain frequency, atoms can get excited from level 1 to level 3 by pumping. The excited atoms in level 3 can make downward transition to level 1 either directly or through level 2 by spontaneous or stimulated emissions. If it comes down through level 2 and rate of transition from level 3 to 2 exceeds than rate of emission between 2 and 1, then the atoms start accumulating in level 2 increasing its population When the rate of pumping exceeds a certain threshold, population inversion is maintained between level 1 and level 2. In this state the frequency of radiation will be amplified by stimulated emission. Here the level 3 is the highest state in which atoms are very unstable and their lifetime is only 10^{-10}sec after which they automatically come down to the lower

level undergoing spontaneous emission process. But state 2 is called as **meta-stable** state in which atoms are more stable (lifetime ~10^{-3}sec), so population inversion can be achieved easily. Level 2 acts as upper laser level and level 1 acts as lower level as lasing emission takes place from level 2 to level 1.This type of technique is used in Ruby laser.



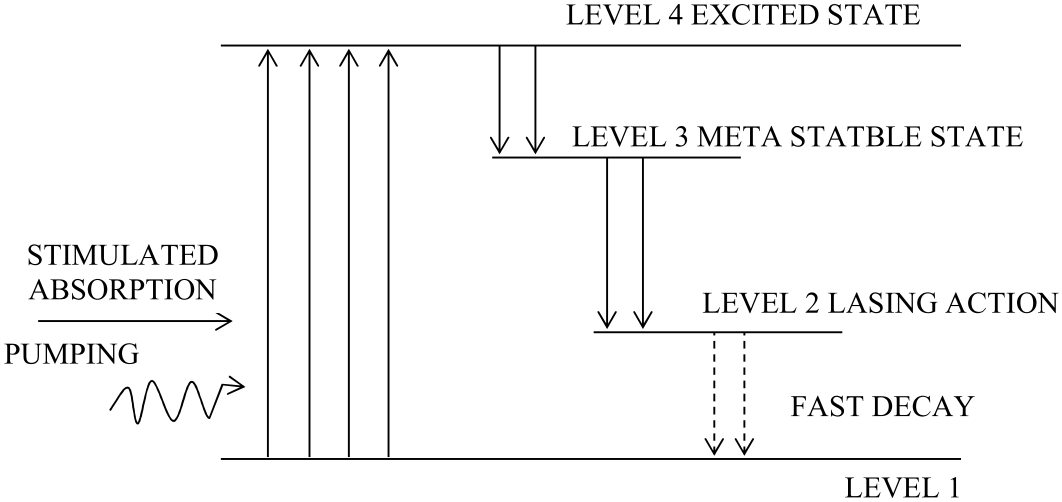
THREE LEVEL LASER SYSTEM

<u>Disadvantages of 3-Level LASER System</u> :

As population inversion has to be maintained between one excited level and ground level, the required threshold pumping power for population inversion is very large and of the order of KW. When the rate of depopulation exceeds the rate of pumping of atoms from ground level to exciting level, population inversion doesn't exist and lasing action ceases. So, for continuous lasing emission, large amount of energy is required for pumping.

b. Four Level LASER System :

A more efficient scheme employed in most lasers is the four-level laser system. Here the level 4 is the highest level If the transition rates from level 4 to 3 and from 2 to 1 are large compared with the transition rate from 3 to 2, then population inversion is maintained between 3 and 2, so lasing transition also occurs between them.



FOUR LEVEL LASER SYSTEM

As ground level is not the lower laser level, so in this case lasing emission is possible even with low to moderate pumping powers. This technique is used in gas lasers like He-Ne laser.

MAIN COMPONENTS OF LASER

For **sustained lasing action**, we need Population inversion, Pumping level should be higher than the threshold value & Positive feedback to compensate losses. In order to make the above facts effective, there are three main components of LASER.

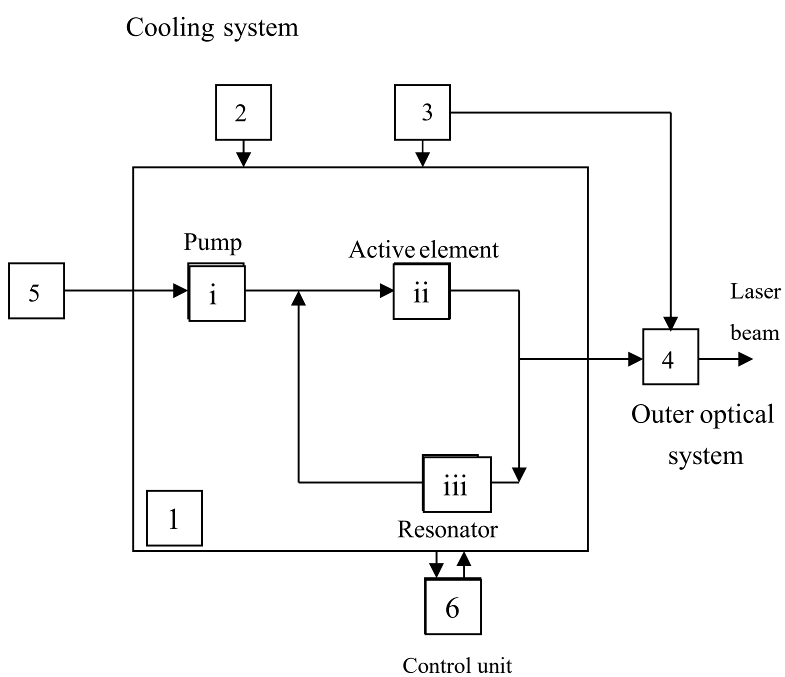
a. **The pumping source**: The source of energy (used for pumping mechanism) which supplies energy for achieving population inversion between a pair of energy level of the atomic system of the active medium is known as pumping source.

b. **The active medium**: The active medium consists of a collection of atoms, molecules, or ions (in solid, liquid or gaseous form), which is capable of amplifying light waves.

Example: The active medium in a solid state LASER is Ruby Rod and in a gas LASER it is He-Ne gas for He-Ne LASER and Carbon Dioxide gas for Carbon Dioxide LASER.

c. **Optical resonator**: As stimulating photon is effective for limited length of active medium, so, to maintain population inversion throughout the active medium, resonator is used. Because of multiple reflection, a single photon serves as stimulator and causes light amplification.

BLOCK DIAGRAM OF LASER UNIT:



1) Lasing Emitter: It consists of

i) active element

ii) Pumping system

iii) optical resonator

2) Cooling System: It is required to cool the system as well as to achieve population inversion at a lower temperature

3) Light Modulation: It is an additional feature to control laser emission.

4) Outer optical system: It shapes the laser output in a particular direction

5) Power source: It supplies electrical power to initiate the pumping process.

6) Control Unit: It controls the whole LASER emission process

CHARACTERISTICS PROPERTIES OF LASER BEAM :

- **a.** The LASER light is highly directional in nature unlike ordinary light for the divergenate or angular speed is very less in LASERS.
- **b.** LASER light is very bright and intense as compared to ordinary light. The brightness of LASER is due to coherent superposition in which intensity increases by n^2 times. Where is n is the number of waves superimposed.
- **c.** LASER light is highly coherent both temporally (w.r.t time) and spatially (w.r.t distance).
- **d.** LASER lights are highly monochromatic.
- **e.** Though LASER emits monochromatic light, but it is not of single frequency and it covers the range of frequencies. However a particular frequency can be tuned for the LASER emission.
- **f.** A LASER can be operated in three standard modes that is, continuous wave, pulse lasing and repetitive pulse lasing (spiking).

DIFFERENCE BETWEEN ORDINARY LIGHT AND LASER LIGHT:

ORDINARY LIGHT	LASER LIGHT
1. Ordinary lights are not monochromatic and hence low spectral purity	1. It is highly monochromatic and hence high spectral purity.
2. Ordinary lights are not coherent.	2. Laser light is Coherent.
3. Due to lack of spectral purity and coherence, output intensity per unit area is diffused and small.	3. Due to high spectral purity and coherence, output intensity per unit area is highly directional and very large.

TYPES OF LASER

There are three types of LASER sources to generate LASER.

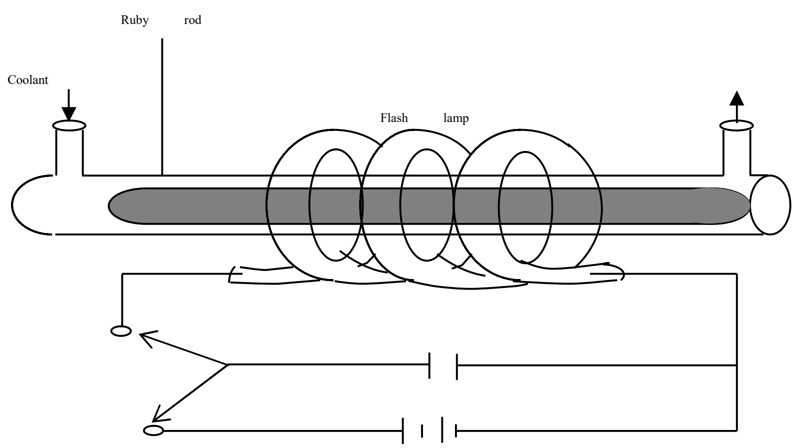
1. Solid State LASER (Ruby LASER).
2. Gas LASERS (He-Ne and CO_2 LASERS).
3. Semiconductor LASERS (Forward biased PN Junction)

SOLID STATE LASER (RUBY LASER)

The first successful laser action was demonstrated by Theodore Maiman in 1960 using a ruby crystal. It is one of the most important solid state lasers. Ruby is a crystal of aluminum oxide (Al_2O_3) in which some of the Al^{3+} ions are replaced by Cr^{3+}ions which are responsible for red colour. The active material is Cr^{3+} ions doped in Al_20_3 (Sapphire) crystal. In this case the ruby crystal in this case contains 0.05% chromium

Construction:

The ruby rod is housed in the glass tube which is surrounded by the helical discharge tube. The capacitor and the d.c. power supply is connected as per the diagram.



Typical setup of a pulsed ruby laser using flash lamp pumping and external mirrors

Pumping: Due to availability of broad energy bands ,optical pumping is mostly used for this kind of laser.

Working Principle :

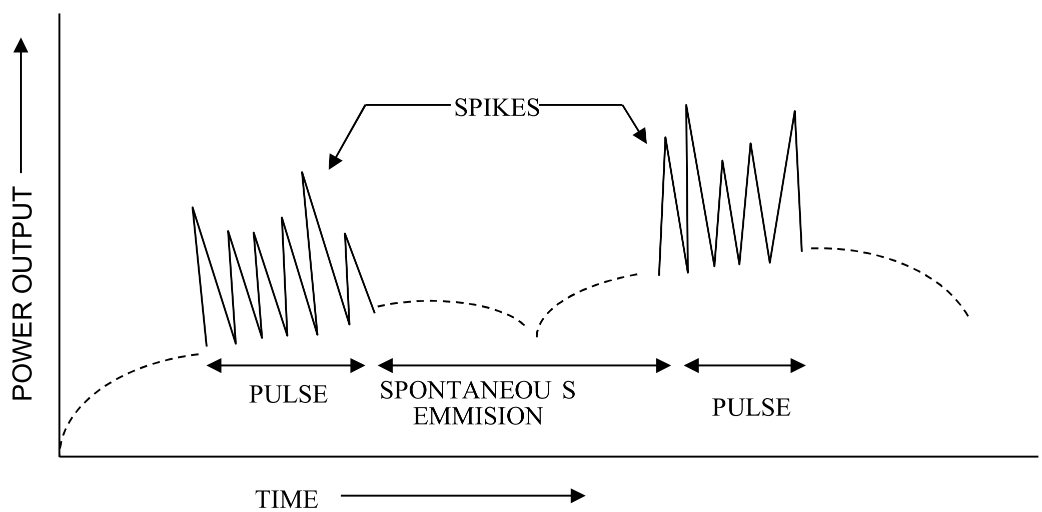
The ruby laser operates in a pulsed mode at 694.3nm with an emission line width of 0.53nm.It is a 3-level laser. When the capacitor discharges through the xenon tube, discharge flash through the xenon tube lasts several milliseconds. Though the tube consumes several thousand joules of energy in a single flash, only a part of the energy is used in pumping the Cr^{3+} ions while the rest heats up the apparatus. So coolant is used.

Operation:

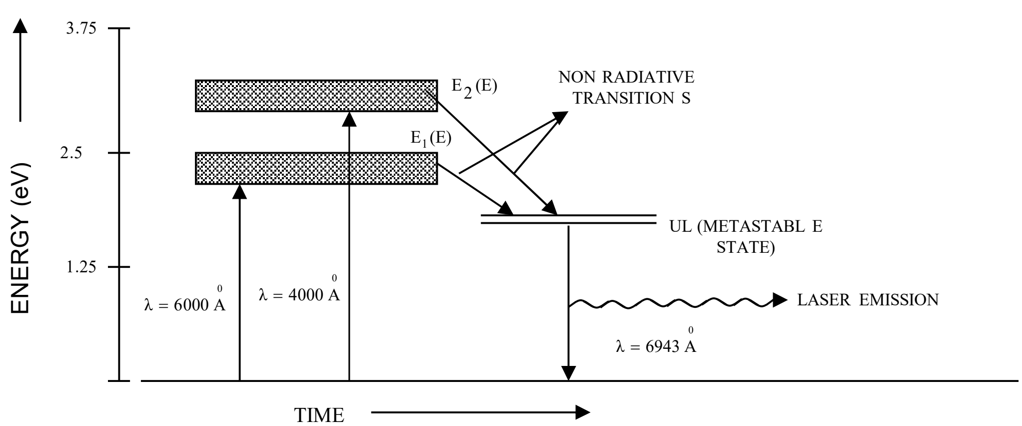
A xenon flash lamp excites the Cr^{3+} ions to a level of higher energy(blue and green) from which they fall to a metastable state (which is splitted into two levels) by undergoing through non-radiation decay and losing energy to other ions in the crystal. Photons from the spontaneous decay of some Cr^{3+} ions are reflected back and forth between the mirrored ends of the ruby rod, stimulating other excited Cr^{3+} ions to radiate. Photons traveling parallel to the axis of crystal increase in number and a flow of photon emission starts resulting in a coherent and monochromatic beam of light which escapes through partial reflecting surface. Photons which travel in any other direction do not contribute towards the laser output.

Spiking in ruby laser:

The flash lamp has duration of excitation of the order of milliseconds and can have an adequate degree of intensity to build up an inverted population very quickly. When the upper laser level has sufficiently large population ,a pulse is produced., then it depletes the upper level before it is restored by the flash lamp.So laser emission ceases for a few microseconds. Since the flash lamp is still in action, population inversion again commences producing another spike and it continues. A large no. of pulses are produced until the intensity of the flash lamp falls down to an extent so that population inversion cannot be rebuilt.



Energy Level Diagram:



Advantages of ruby laser:

1) The crystal is hard and durable.2)It has good thermal conductivity3)It is chemically stable4)The laser crystals ,from which the rods are formed , can be grown with high degree of optical qualities.

Applications of Ruby laser:

1) Distance measurement using *pulse echo* technique.

2) Recording holograms of large volume in a single ruby laser pulse.

3) Atmospheric ranging, scattering and radar measurements.

4) Drilling small holes with precise dimensions and for laser welding

5) Target location in military

6) Trimming resistors and IC circuit masks.

7) Melanin and tattoos of the skin can be removed

8)Research application such as measurements of plasma properties(i.e. electron density and temperature)

GAS LASERS

Gas lasers fall in the category of lasers involving low-density gain media .Depending upon the active medium, the gas lasers can be categorized into *atomic*, *ionic* and *molecular* lasers.

Examples of gas lasers are He-Ne,CO_2, exciter, copper vapour, nitrogen, Argon-ion and He-Cd lasers etc.

Principle:

The gas lasers require a mixture of two gases A and B such that some excited level of A falls close to an excited level of B. The gas discharge in the mixture excites the gas A. Now collisions transfer the excitation to B. This produces the laser beam.

Pumping:

These lasers are mostly pumped by electric discharge accelerates the electrons and makes them collides with atoms, ions or molecules of the active medium. This causes transitions to higher energy states.

For efficient optical pumping broad energy bands must be available which is not found in gaseous medium and hence for pumping in gas lasers electric discharge is usually used. In optical pumping polychromatic light is produced by flash lamp which can be absorbed by solids due to their energy bands. So, optical pumping is preferred in solid lasers.:

Construction:

For a gas laser to be of practical use, there should be a container of gas usually made of glass, so it becomes transparent towards the expected radiation When we apply a strong magnetic field across the gas the electrons which are on the move and the ions accelerate and collide with gas molecules. A higher voltage is essential to initiate the discharge than to maintain it.

Gas discharge: In order to produce ionized and excited molecules, all that As the electron impact required is to apply a high voltage discharge in a tube. The atoms that are excited subsequently, will start emitting light. This process is called as *gas discharge*

HELIUM-NEON LASER

The first successful demonstration of a gas laser was done by Ali Javan and his colleagues in the Bell Tel. Lab. in 1961 using a mixture of helium and neon. The He-Ne laser is a 4-level gas laser. He and Ne are mixed in the ratio 10:1 and enclosed in a glass tube at a pressure of 1Torr.The laser action takes place in the energy levels of the neon atoms. He atoms help to achieve population inversion by imparting their energy to the Ne atoms by resonant energy transfer.

Pumping:

In He-Ne laser pumping is achieved by producing an electric discharge through the gas. Electrodes are placed close to the He-Ne tube and a source of high frequency

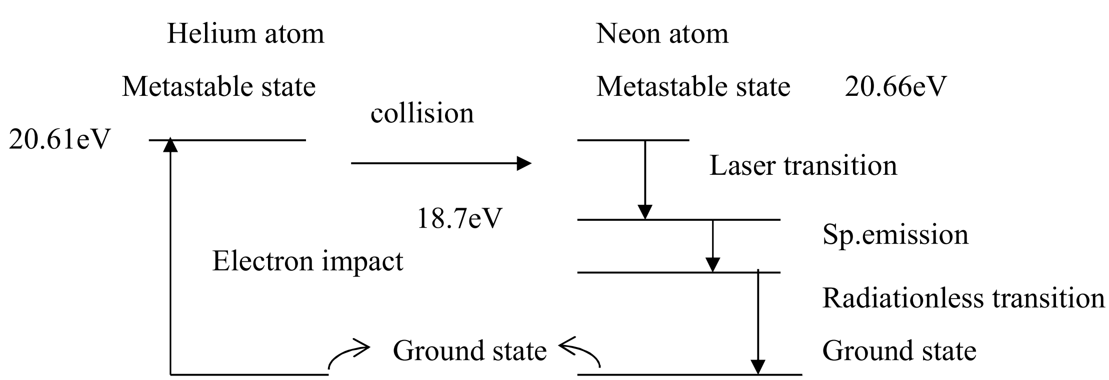
Construction:

A mixture of about 10 parts of helium and 1 part of neon at a low pressure (~1torr) is placed in a glass tube that has parallel mirrors ,one of them partly transparent ,at both ends .The spacing between the mirrors (as in all lasers) is equal to an integral number of half-wavelengths of the laser light.

Working principle

An electric discharge is produced in the gas by means of electrodes outside the tube connected to a source of high frequency alternating current, and collisions with electrons from the discharge excite He and Ne atoms to metastable states respectively 20.61 and 20.66eV above their ground states .Some of the excited He atoms transfer their energy to ground state Ne atoms by inelastic collisions, with the 0.05eV of additional energy being provided by the K.E. of the atoms. The purpose of using He atoms is thus to help achieve population inversion in the Ne atoms. The laser transition in Ne is from the metastable state at 20.66eV to an excited state at 18.70eV , with the emission of a 632.8nm photon. Then another photon is spontaneously emitted in a transition to a lower metastable state ;this transition produces only incoherent light. The remaining excitation energy is lost in collisions with the tube walls. As the electron impacts that excite He and Ne atoms occur all the time ,(unlike the pulsed excitation from the xenon flash lamp in a ruby laser) a He-Ne laser operates continuously. In this laser only a fraction of atoms present, take part in the laser process at any moment.

Energy level diagram



Features of He-Ne Laser

1) He-Ne laser is a continuous laser
2) Its power range is 1 to several mW
3) Wavelength of laser is 6328A°(red)

Application of He-Ne laser:

It is used in the field of

1) Interferometry 2) laser printing 3) bar code reading
4) pointing and directional reference beams.

Advantages of gas lasers:

1) Smaller line width of optical transition
2) Narrower (spectrally) laser emission.
3) Higher Q-factor of the mode.
4) Better coherence.
5) Better optical quality as no optical inhomogenities.
6) Higher monochromaticity

Disadvantages:

Gas lasers are unsuitable in the field of micro optics for their large size, high voltage supply, low efficiency and complex pumping device.

SEMICONDUCTOR LASER

In its simplest form, a semiconductor laser consists of a forward biased p-n junction, formed in a direct band gap semiconductor .The recombination of injected carriers such as electrons and holes, in the junction region results in the emission of photons. The cleaved ends of the laser structure act like mirrors forming a resonator along the p-n junction. The other two ends are saw-cut to reduce reflections from these ends and prevent lasing along the perpendicular direction. When the forward current through the diode exceeds a critical value known as the *threshold current,* optical gain in the resonator due to stimulated emissions overcomes the losses in the resonator, leading to net amplification and to steady state laser oscillations.

Principle

In a forward biased p-n junction diode, holes crossing over to N-side and electrons crossing over to P-side have probability of electron–hole combination with release of energy. In elementary semiconductors like Si and Ge the energy is liberated in form of heat energy whereas in case of compound semiconductors like GaAs and InP, recombination results in emission of photons This

phenomenon is known as electroluminescence and is the basic of LED and diode laser. But in laser to obtain stimulated emission strong bias is applied to heavily doped semiconductors.

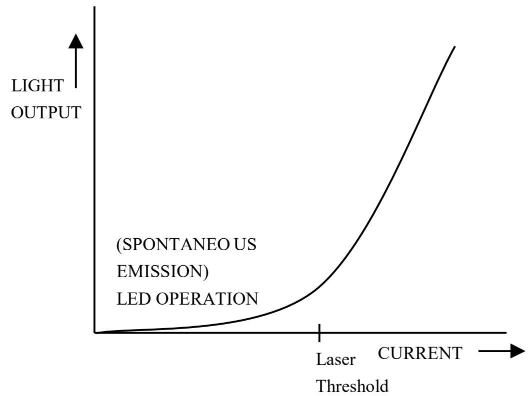
Pumping and population inversion

In a diode laser a pn junction formed from very heavily doped p and n materials provides the active medium. When forward bias is applied to the junction diode, the bias current performs the role of pumping agent. As a result of forward bias, electrons holes are injected into the junction region. At low forward current level, electron- hole combination causes spontaneous emission of photons and the junction acts as an LED. When the current reaches a threshold value, the carrier concentration reach to very high values within the depletion layer and the state of population inversion is established. There is large concn. of electrons within the C.B. and a large concn. of holes within the V.B. of the active region. The photons emitted by spontaneous emission induce the electrons of C.B. to jump into the holes of V.B.. These stimulated electron-hole recombination cause emission of coherent radiation. The st. emission is confined to a particular direction by the reflective surfaces formed perpendicular to the junction. The reflective surfaces are the smooth “facets” formed cleaving the chip. Semiconductors have high refractive indices and the facets reflect about 30% of the light back into the material providing enough feedback for laser action.

Working

When forward voltage grater than the gap voltage is given, the Fermi level separates out .In heavily doped N-type material, it lies inside the C.B. and becomes $E_{Fn.}$ In case of heavily doped P-type semiconductor, the new Fermi-level is E_{Fp} and lies inside V.B. With small exciting current recombination of electrons from $E_{Fn.}$(higher level) with the holes of E_{Fp} (lower level) occurs emitting photons through spontaneous emission .But when the exciting current reaches the *threshold current* (a minimum value),the gap (E_{Fn}- E_{Fp}) becomes large compared to E_g, hence emitted photons carry sufficient energy and collision with excited electrons bounce back and forth from the cleaved surfaces of the mirrors. The emitted photons may interact with electrons of V.B. causing stimulated absorption or it may interact with electrons of C.B. resulting stimulated emission. Loss due to absorption is overcome and amplification of light takes place in a small region within the depletion region of size 1μm.This region is called as **active region**. The photons emitted in the process will carry energy E_g=hν .

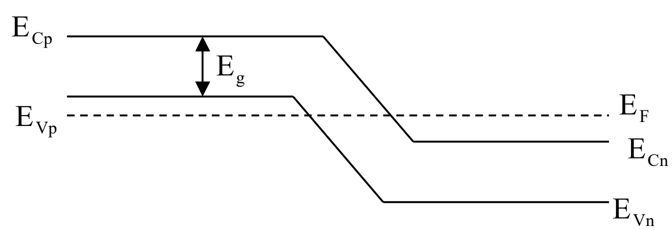
Feedback-Due to high refractive index of these materials (for example,≤3.6 in case of GaAs) the end faces themselves act as reflecting surfaces no external mirror is required for optical feedback.



Characteri stic of an ideal diode laser.

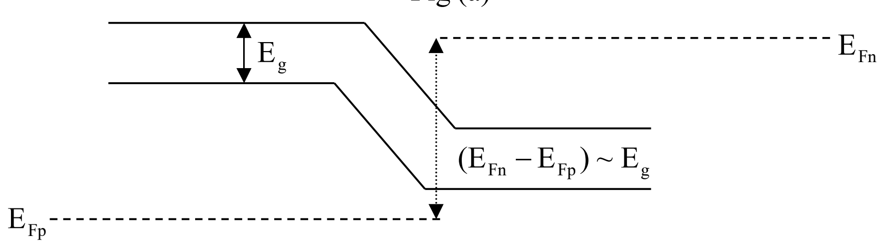
High divergence-The size of the active region from where laser output comes out is comparable with the visible light. Hence this region behaves like a narrow aperture and causes diffraction effects to light waves. So laser light from diode laser shows maximum divergence.

Energy Level Diagram



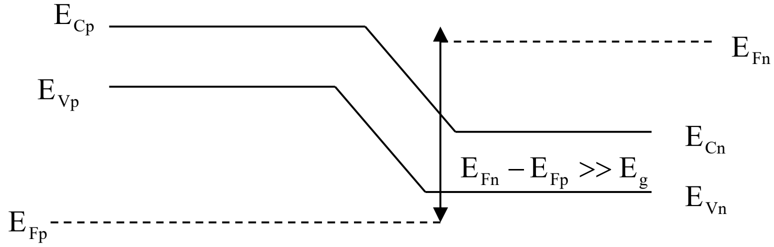
Equilibrium condition

Fig (a)



Forward biased condition

Fig (b)



Lasing condition

Fig (c)

(Band diagram of a heavily doped PN junction)

Advantages of the semiconductor laser:

1) Small size and small mass
2) High optical amplification
3) High output efficiency
4) Simple pumping method
5) Suitable for microelectronic and optoelectronic device
6) Large quantum efficiency as electric energy is converted into light energy directly
7) Emission at the specified wavelength in a wide range

Disadvantages of the semiconductor laser

1) Short service life (not exceeding 10^2-10^3 hours practically)
2) High divergence
3) Short length of the resonator
4) Small exit aperture

Application of semiconductor laser

1) Classroom experiment and research
2) used as light source in optical fiber for long distance communication
3) CD players
4) High speed printing
5) Pump source for other lasers
6) Used as probe that reads data from CD

Application of LASER

1) LASERS in mechanical industry:

a) Drilling b) Cutting c) Welding d) Heating Treating

2)LASERS in electronics industry:

a) Scribing b) Soldering c) Trimming d) Photolithography

3) LASERS in nuclear energy

a) Isotope separation b) Nuclear Fusion

4) LASERS in medicine:

(i) LASES are used in ophthalmology to correct posterior capsular opacification.

(ii) Nd-YAG LASERS can be used for LASER prostate surgery

5) LASER in Defence:

i) The optical radars, using laser beams are employed in detecting distant objects and collecting information about them. This is known as range finding

ii) Nowadays, low flying aircrafts are used in ground attacks. They are fitted with laser instrumentation for measuring the target, and guiding the bomb onto it thereby reducing the human element to the minimum.

iii) Laser weapons may disable the enemy weapons or destroy them. The missiles can be damaged after detection by laser weapon. It is done by intercepting the missile and make it inoperative.

6) LASER in measurement of distance:

i) Large distance can be measured to a very high accuracy using laser beam.

ii) Large distance can be measured using pulse technique. The technique is often known as optical radar or LIDAR (light detection and ranging)

7) Velocity measurement: Laser Doppler velocity meters are used for measuring fluid flow rates.

8) HOLOGRAPHY:

It is the technique in which both the phase and intensity attributes of the wave received from a three dimensional object are recorded This record is called as hologram. When this record is illuminated to a coherence light, the three dimensional photograph is obtained.

Applications of different kind of LASERS:

1) He-Ne laser is used in interferometry, laser printing, bar code reading, and as pointing and directional reference beams. The 1.15μm laser emission of He-Ne laser can be used for measurements of optical fibre transmission line, which have a minimum loss in that wavelength region.

2) Argon-Krypton lasers are used for phototherapy of the eye, for pumping in Dye lasers, laser printers, stereolithography etc.

3) CO_2 laser is used in the general field of material processing like cutting, drilling, etching, melting, welding, alloying, annealing, hardening etc.

4) Dye lasers finds its application in study of atomic physics , in photochemistry and in emission & absorption spectroscopy.

5) Ruby laser is used in holography, in studying plasma properties like electron density and temperature. It is also used in removing tattoos and melanin of the skin.

6) Semiconductor lasers find their application in long distance communication using optical fibre, in CD players, as probe or needle which reads the information from the compact disc. They are also used in high speed printing, free space communication, and as a pump source for other solid state lasers.

7) Nd-YAG lasers are used for drilling, spot welding, laser marking, resistor trimming, circuit mask, memory repair. These are widely used in medical fields such as gall bladder surgery, membrane cutting,. These lasers are also used in military applications like range finding and target designation.